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Research article

A sectoral perspective on international climate governance: Key findings and research priorities

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ABSTRACT

This concluding article derives six major findings from the contributions to this special issue. First, the barriers and challenges to decarbonisation vary significantly across sectoral systems. Second, and similarly, the need and potential for the five functions of international governance institutions to contribute to effective climate protection also vary widely. Third, while the pattern is uneven, there is a general undersupply of international climate governance. Fourth, the sectoral analyses confirm that the UNFCCC and Paris Agreement play an important overarching role but remain limited in advancing effective sectoral governance. Fifth, while non-environmental institutions may present important barriers to decarbonisation, more synergistic effects are possible. Sixth, our sectoral approach provides a sound basis on which to identify sector-specific policy options. The paper then offers reflections on the merits and limitations of the sectoral approach, before identifying avenues for future research to further advance the agenda.

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1. Introduction

The increasingly polycentric landscape of international climate governance can appear rather amorphous, presenting challenges to those assessing its overall effects. While the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement still play a central role, the governance landscape has grown much more diverse, featuring a greater number of international institutions, including transnational ones that comprise subnational and non-state actors. The complex shape of this landscape makes assessments of its adequacy, i.e. to what extent the potential for effective international governance is being exploited, difficult. First attempts to assess its structure have been made (see *inter alia* Widerberg et al., 2016; van Asselt 2014) and individual contributions have subdivided specific institutional complexes into various subgroups according to particular sub-fields or governance

functions (Oberthür and Pożarowska 2013; Orsini et al. 2013). Yet the interplay between the growing number of intergovernmental and transnational institutions of climate governance – the synergies but also potential conflicts – has yet to be studied in a systematic way (Betsill et al., 2015).

To this end, this special issue proposes a focus on *sectoral systems* as a means for a more systematic distinction and structuring of our understanding of polycentric global climate governance. It specifically investigates the potential and actual contribution of global governance to facilitate the transformation of sectoral systems towards decarbonisation, taking into account five key governance functions international institutions can perform (guidance and signal, setting rules and standards, transparency and accountability, means of implementation, knowledge and learning). This set-up allows us to structure the amorphous climate governance landscape and renders it susceptible to more detailed analysis. It facilitates the identification of specific sectoral needs and potentials, and the study of interdependencies, synergies and trade-offs between the various elements of the landscape affecting the sectoral systems in focus (Oberthür, Hermwille & Rayner, this

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issue). The added value of this approach has been tested and demonstrated in five case studies on different sectoral systems, covering power (Hermwille, [this issue](#)), energy-intensive industries (Oberthür, Khandekar and Wyns, [this issue](#)), fossil fuel extractive industries (Rayner, [this issue, a](#)), international transport (aviation and shipping: Rayner, [this issue, b](#)), and land transport (Obergassel et al., [this issue](#)). The framework was also applied to the cross-cutting sectoral system of global finance which is not featured in this Special Issue.¹ A reference to these sectors in the following implies a reference to the respective sectoral analyses included in this special issue.

It is no surprise that our research shows an overall shortfall of global climate governance across all cases. But our systematic diagnosis allows us to distil six major findings of *how and why* the potential of global climate governance remains underexploited. First, sectoral systems are found to display varying economic, technical, political and institutional barriers and challenges to decarbonisation. Second, and consequently, sectoral systems have specific needs and potentials for the five functions of international governance institutions to contribute to effective climate protection, with wide variation. Third, the governance potential is unevenly exploited across both sectoral systems and governance functions. Fourth, the sectoral analyses illustrate how the UNFCCC and Paris Agreement, despite their important overarching role, remain limited in advancing effective sectoral governance. Fifth, a range of non-environmental institutions create or reinforce important barriers to decarbonisation, but in some cases have a more synergistic effect and potential. Sixth, our sectoral approach provides a sound starting point for a systematic identification of sector-specific policy options for advancing global climate governance, as outlined by contributors to this special issue. We then offer reflections on the merits and limitations of the sectoral approach, before identifying avenues for future research to further advance this approach.

2. Not all sectors are alike (I): sectoral transformation challenges and barriers

The systematic analysis of the five sectoral systems has enabled us to diagnose sector-specific transformation challenges and barriers, and allowed us to pinpoint some commonalities but also important differences between them. The findings are synthesized in [Table 1](#).

Economic barriers are important in all sectors but vary significantly. For example, higher marginal costs of low-carbon technologies and practices are key in some sectors such as for energy-intensive industries and international transport. As most energy-intensive industries are highly exposed to international trade, the cost of nationally legislated climate action could endanger their international competitiveness. In other sectors, marginal costs of mitigation options are low over their lifetime but upfront investment requirements are high and constitute a challenge (e.g. renewable electricity in the power sector). This especially poses problems for actors and countries with limited access to capital. Perceived risks are also significantly holding back low-carbon investments across sectoral systems. One further challenge for decarbonisation concerns the manner in which the growth of activity in the transport-related sectors (and their associated emissions) is strongly coupled historically with rising incomes and increased trade.

¹ This study of global finance and its relationship to the Paris Agreement (see Kretschmer, 2021) revealed significant challenges in applying the sectoral framework to cross-cutting sectoral systems whose boundaries cannot be clearly delimited. The issue is further discussed in section 8 below.

Similarly, **political and institutional barriers** are prominent in all sectoral systems investigated, dominated as they are by large incumbent corporations, whether privately or publicly owned. These incumbents often fiercely protect their established business models and wield significant political influence (at times with very close association to governments, as is the case for nationally-owned oil companies or legacy car manufacturers). Consequently, appropriate regulatory frameworks are frequently lacking. In many cases, existing institutions actually still promote high-emission technologies and practices, having co-evolved with them over decades. In addition, managing the distributional effects of climate mitigation can present formidable challenges, particularly where whole economic sectors and regions (such as areas entirely depending on fossil fuel extractive industries) are at stake.

The significance of **technological barriers** varies across the analysed sectoral systems. For some, they are not (any longer) a major transformation challenge. For example, technical solutions largely exist in power production and land-based transport, even if technological challenges remain in specific areas (including system integration and large-scale deployment). In contrast, technological alternatives that enable a full decarbonisation of energy-intensive industries and international transport (aviation in particular) are yet to be fully developed and proven.

Awareness, information and capacity are key barriers in most sectors. Awareness of problems, information about mitigation options and effective policies, and the technical skills of the work force need to be improved across the board (with somewhat varying prominence of these elements across sectoral systems). Investment decisions across our sectoral systems continue to be guided in many cases by short-termist expectations, while climate change impacts will be felt most significantly in the long-term. This dilemma was dubbed the 'tragedy of the horizon' by Mark Carney, former Governor of the Bank of England (Carney 2015). Accordingly, one of the core challenges is to provide the means and information for decision-making to better reflect the 'social cost of carbon' and address the growing risks of a 'carbon bubble' (McGlade and Ekins 2015; Mercure et al., 2018).

3. Not all sectors are alike (II): varying potential of international governance

As with the challenges and barriers, the potential for international governance to address them varies across sectors. The sectoral approach allowed us systematically to assess the potential of global governance per sector per governance function. The results of the analysis are summarized in [Table 2](#). In the following, we discuss the specific potential of international governance to contribute to sectoral decarbonisation for each of the five governance functions distinguished according to the case studies. Overall, we find that significant potential exists in all sectoral systems.

The rationale for providing clear **guidance and signal** towards decarbonisation is common to all sectoral systems. The Paris Agreement establishes the aim to phase out global net GHG emissions in the second half of this century, which will have to be reached as early as possible to maximise the chances of global average temperature rise remaining below 2/1.5 °C. It may not necessarily be clear to key sectoral actors, however, what precisely this means for them. For example, while big electricity producers can conclude that the use of renewable energy needs to increase dramatically and the (production and) use of unabated coal power needs to end sooner rather than later (Yanguas-Parra et al., 2019), the implications for gas-fired power generation are far less clear. Utilizing fossil gas as a 'bridge' fuel may have short-term climate benefits over coal-fired alternatives, but risks 'locking in' yet another fossil fuel-based infrastructure (Tanaka et al., 2019;

Table 1
Overview of sector-specific transformation challenges and barriers.

Sectors	Financial and Economic	Institutional and Political	Technological	Awareness/Information/ Capacity
Power	<ul style="list-style-type: none"> • High upfront RE investment costs • Cost of re-building grid infrastructure 	<ul style="list-style-type: none"> • Blocking power of incumbents • Appropriate market regulation/design 	<ul style="list-style-type: none"> • Intermittency of wind/solar • Storage solutions • New grid infrastructure 	<ul style="list-style-type: none"> • Lack of skilled workers
Energy-intensive industry	<ul style="list-style-type: none"> • High capital requirements, long investment cycles, and technology risk • Complexity of global value chains 	<ul style="list-style-type: none"> • Fear of losing competitiveness/stunting development • Lack of policy frameworks 	<ul style="list-style-type: none"> • Lack of mature low-carbon technologies • Technological inertia, insufficient R&D spending 	<ul style="list-style-type: none"> • Lack of information on complex/global supply and value chains
Extractive Industries	<ul style="list-style-type: none"> • 'Resource curse': unwillingness by investors to invest in other sectors • Cost of transition for extraction-reliant regions • Risk of stranded assets 	<ul style="list-style-type: none"> • Power of incumbents • High fossil-fuel subsidies • Distributional conflicts re. foregoing resource rents and subsidies 		<ul style="list-style-type: none"> • Lack of transparency on fossil fuel subsidies (FFS). • Lack of govt. capacity to substitute FFS by more targeted policies • Lack of capacity to devise alternative national/regional development paths
Land Transport	<ul style="list-style-type: none"> • Very high infrastructure expenditure required • Higher upfront costs of new vehicle technologies • Growth in transport and economic growth strongly correlated 	<ul style="list-style-type: none"> • Dominance of high-emission policy and planning paradigms (e.g. segregated land-use, priority for road-based transport) • 'Road lobby' influence (manufacturers, hauliers, oil companies etc) • Lack of technical standards for EVs 	<ul style="list-style-type: none"> • Longevity of transport infrastructure • Need to adapt electricity grid to cope with increasing loads and shifts in demand profile • Need for common standards for charging solutions • Need to adapt vehicle servicing infrastructure 	<ul style="list-style-type: none"> • 'Car culture' • Lack of capacity esp. in rapidly urbanising areas in Global South
International transport	<ul style="list-style-type: none"> • High cost of low-carbon alternative fuels relative to (untaxed) aviation and shipping fuels • Split incentives between ship owners and hirers • Growth in transport and economic growth/trade strongly correlated. 	<ul style="list-style-type: none"> • Effort-sharing controversy – what is a fair share? • Power of incumbents • Complexity of supply chain restructuring needed for e.g. slow steaming 	<ul style="list-style-type: none"> • Technical problems regarding use of biofuels, hydrogen, electricity • Insufficient R&D spending/coordination 	<ul style="list-style-type: none"> • Lack of information on mitigation potentials for shippers • Perceived individual 'right to fly' • Low profile of shipping lessens public pressure

Source: authors, based on sectoral case studies.

Howarth 2014). Sector-specific targets and roadmaps (potentially further specified for particular regions, as suggested for energy-intensive industries and transport) could generally make global long-term goals more tangible for sectoral actors and more difficult to ignore. This can be particularly helpful where sectors feature many small and medium-sized actors with limited strategic capabilities, as is the case for parts of the transport sector. In general, the more concrete targets are, the more suitable they tend to be for providing effective guidance to relevant sectoral actors.

The need for **setting rules and standards** to facilitate collective action varies across the sectoral systems investigated. In some sectors, international competition and/or interdependence provide a strong and even compelling rationale for international regulation that ensures a level-playing field (e.g. energy-intensive and fossil-fuel extractive industries, including removal of fossil-fuel subsidies; international aviation and shipping). In other cases, the rationale for international rules and standards is much weaker. In the power sector, for example, competitiveness concerns have lost weight with the startling decline in the cost of renewable electricity technologies in the 21st century. Still, international standardization may facilitate the integration of electricity grids across national borders on a regional scale. Furthermore, international regulation could prompt action by governments which may not otherwise see decarbonisation as a priority. In such cases, it may well need to be accompanied by the provision of sufficient means of implementation. For example, emerging or developing economies may be prompted to take steps to decarbonise certain sectors, provided that international assistance is available.

Transparency and accountability are closely linked to the need for international regulation and its underlying rationale since they

specifically relate to the implementation of agreed rules and standards (see Oberthür, Hermwille and Rayner, *this issue*). A basic level of transparency is also required to be able to adopt common rules and standards in the first place. Once they have been agreed, the demand for transparency and accountability is particularly pronounced where international competition and interdependence provide a strong motivation for free-riding, or where emissions occur at multiple points in a lifecycle that extends beyond the confines of a particular sector (as in low-carbon fuel production). Hence, international transport and energy-intensive industries feature a high demand for transparency and accountability to support effective implementation of international regulation. In contrast, there may be less need for specific arrangements, where regulated activities are intrinsically relatively transparent (as with fossil-fuel extractive industries) or where regulation is quasi self-enforcing (e.g. technical standards for electric vehicles) (see also Mitchell 1994).

The need for the provision of adequate **means of implementation** is generally high across the sectoral systems, but with significant variation across different means. Financial means of implementation are in demand in most sectors, but in varying forms. In energy-intensive industries, financial support may be required for breakthrough technologies even in developed countries, while in other cases demand for financial transfers especially exists in developing countries (transport). In some sectors, such as extractive industries, key actors may themselves in principle already dispose of sufficient financial resources to embark on transitions. Meanwhile in the power sector, sustainable alternatives might even be cost competitive over their lifetime but are impeded by high upfront capital requirements. International cooperation

Table 2
Overview of sector-specific governance needs.

Sectors	Guidance & Signal	Rules & Standards	Transparency & Accountability	Means of implementation	Knowledge & Learning
Power	<ul style="list-style-type: none"> Signal for low-carbon investments in energy infrastructure. 	<ul style="list-style-type: none"> Coordinated target setting (decreasing importance due to RE cost fall) Coordination at regional level (esp. grid development) 	<ul style="list-style-type: none"> Required to support collective action function 	<ul style="list-style-type: none"> financial risk sharing international transfer of RE and storage technologies admin. and technological capacity building 	<ul style="list-style-type: none"> sharing of good practice policies e.g. on market designs and long-term planning
Energy-intensive industry	<ul style="list-style-type: none"> Sectoral decarbonisation objectives and roadmaps 	<ul style="list-style-type: none"> International emission limits and/or carbon pricing 	<ul style="list-style-type: none"> Required to monitor and verify implementation of rules 	<ul style="list-style-type: none"> Financing of breakthrough technologies, technology transfer and R&D coordination 	<ul style="list-style-type: none"> Policy learning, supply and value chains
Extractive Industries	<ul style="list-style-type: none"> Signal phase out of fossil fuel extraction asap after 2050; of subsidies by firm deadline Share information about climate-related investment risk 	<ul style="list-style-type: none"> Global regulation of extraction rights/sequencing of phase-out/any associated compensation Rules on FFS phase-out incl. definition of FFS 	<ul style="list-style-type: none"> Monitoring implementation of global regulation Internationally comparable (FFS) data 	<ul style="list-style-type: none"> Technical and financial support for national reform efforts (transition away from extractive industry, FFS reform efforts) 	<ul style="list-style-type: none"> Raise awareness of carbon bubble/stranded asset risk Policy learning regarding damage from existing, benefits of alternative, development paths.
Land Transport	<ul style="list-style-type: none"> Decarbonisation international target/roadmap (differentiated) 	<ul style="list-style-type: none"> Common technical standards (e.g. for electric vehicles) Regulation, e.g. emissions control, carbon pricing, climate budget reform 	<ul style="list-style-type: none"> Needed for emission limits and carbon pricing 	<ul style="list-style-type: none"> Financial risk-sharing for large infrastructure projects Finance, technology and capacity building 	<ul style="list-style-type: none"> Learning partnerships (especially North-South cooperation) on technologies and policy design
International transport	<ul style="list-style-type: none"> Global limits and phase-out of (net) emissions (with differentiation) Define net zero 	<ul style="list-style-type: none"> Global limits on emissions Internalising external costs Operational and technological prescriptions Phase-in periods/compensation for developing countries 	<ul style="list-style-type: none"> To ensure effective implementation of international rules (and allow appropriate rules to be set) Full lifecycle accounting 	<ul style="list-style-type: none"> Technical cooperation/technology transfer (shipping) Access to capital/finance, e.g. for retrofits (shipping) Finance/subsidy of R&D Institutional capacity building 	<ul style="list-style-type: none"> (Joint) R&D for low-carbon technologies/fuels Info on new tech/operational measures (shipping) Awareness raising, including on policy co-benefits

Source: authors, based on sectoral case studies.

may help de-risk the investments required, especially in countries with unfavourable investment conditions. International cooperation on technology and innovation/technology transfer may be particularly warranted in sectors in need of new technologies for the climate transition (energy-intensive industries, transport, international aviation). Phasing out old unsustainable technologies and practices in as just a way as possible has been identified as a major challenge in most sectors, but the fossil fuel extractives sectoral system is unique in that, ultimately, the whole industry needs effectively to be phased out. In all likelihood, corresponding structural adjustments in the host countries/regions will require technical and financial support also at the international level. Finally, there is strong demand for capacity building across all sectoral systems, but this is highly specific and diverse in nature (e.g. incorporating technical skills, policymaking capacity, infrastructure to implement policy instruments, etc.).

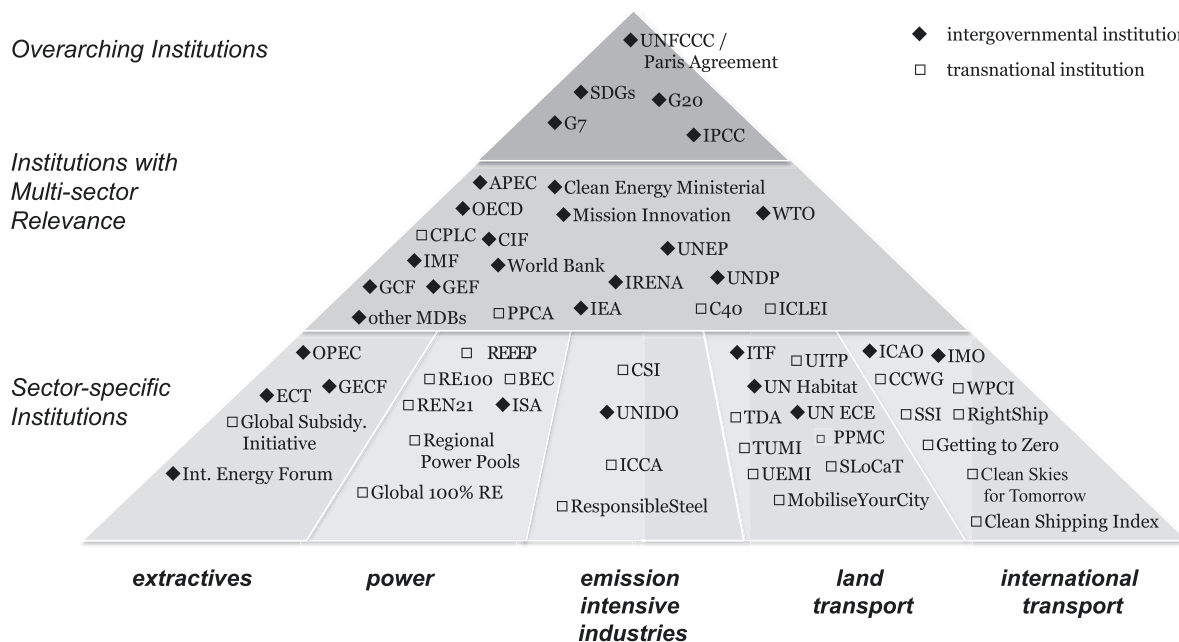
The need for international cooperation for **knowledge and learning** also significantly varies across sectoral systems. In some sectoral systems, there is a particular need for awareness raising and knowledge creation. For example, awareness and knowledge of the risks of investments in “unburnable carbon”, stranded assets and related financial risks are still low in the extractive industry sectoral system. Similarly, understanding of the interdependencies of global supply and value chains of energy-intensive industries as well as technological solutions for the decarbonisation of international aviation remain lacking. For some sectors, technology development, demonstration and research coordination seem key (international transport, energy-intensive industries). In most sectors, there is a considerable potential for promoting technical

and/or policy learning across countries and jurisdictions. In some cases, specific demand for the creation of particular information or data exists (extractive industries, international transport).

Overall, the sectoral approach thereby also illustrates and reflects the diversity of the potential of international institutions to respond to varying challenges. In so doing, it aligns with critiques of the tendency to view the dilemmas of international climate policy exclusively through the lens of the collective action paradigm (Aklin and Mildenberger, 2020; Hale, 2020), especially concerning rule setting and related transparency and accountability. Our analysis demonstrates that collective action problems do play a role in certain sectoral systems (or components thereof), and that their relevance depends on sectoral characteristics as they evolve over time (see Table 2). In contrast, other sectoral systems are characterised by different problem structures and hence needs and potentials for international governance.

4. Specifying the gaps in international governance

Our systematic assessment reveals the diversity, shape and composition of the climate governance landscape across sectoral systems (see Fig. 1). In power and land-based transport, a plethora of sector-specific and more overarching institutions – both inter-governmental and transnational – contribute to climate governance, with no clear hierarchy among them. The other sectoral governance landscapes feature far fewer institutions, in particular far fewer transnational ones. In this respect, governance of international aviation and shipping is more centralized, with ICAO and IMO assigned the lead, respectively. Such a centre of authority and

**KEY:**

UNFCCC	United Nations Framework Convention on Climate Change	ECT	Energy Charter Treaty
SDGs	Sustainable Development Goals	REEEP	Renewable Energy and Energy Efficiency Partnership
G20	Group of Twenty	ISA	International Solar Alliance
G7	Group of Seven	BEC	Breakthrough Energy Coalition
IPCC	Intergovernmental Panel on Climate Change	RE100	RE100 global corporate leadership initiative
APEC	Asia-Pacific Economic Cooperation	REN21	Renewable Energy Policy Network for the 21st Century
OECD	Organisation for Economic Co-operation and Development	CSI	Cement Sustainability Initiative
WTO	World Trade Organisation	UNIDO	United Nations Industrial Development Organisation
CPLC	Carbon Pricing Leadership Coalition	ICCA	International Council of Chemical Association
CIF	Climate Investment Funds	ITF	International Transport Forum
GEF	Global Environmental Facility	UITP	International Association of Public Transport
UNEP	United Nations Environment Programme	UN ECE	United Nations Economic Commission for Europe
UNDP	United Nations Development Programme	PPMC	Paris Process on Mobility and Climate
IMF	International Monetary Fund	TUMI	Transformative Urban Mobility Initiative
IRENA	International Renewable Energy Agency	SLoCaT	Partnership on Sustainable Low Carbon Transport
IEA	International Energy Agency	UEMI	Urban Electric Mobility Initiative
GCF	Green Climate Fund	TDA	Transport Decarbonisation Alliance
MDBs	Multilateral Development Banks	IMO	International Maritime Organisation
C40	C40 Cities Climate Leadership Group	ICAO	International Civil Aviation Organisation
ICLEI	ICLEI – Local Governments for Sustainability	WPCI	World Ports Climate Initiative
PPCA	Powering Past Coal Alliance	SSI	Sustainable Shipping Initiative
OPEC	Organisation of Petroleum Exporting Countries	CCWG	Clean Cargo Working Group
GECF	Gas Exporting Countries Forum		

Fig. 1. Overview of international institutions governing selected sectoral systems.
Source: Derived from case studies.

policy-making seems absent in the governance of extractive industries and energy-intensive industries. Very few international institutions address specifically energy-intensive industries. Fig. 1 provides an overview of the institutional landscape relating to the sectors covered in this special issue.

Regardless of their varying institutional density, a significant potential for international governance remains untapped in all sectoral systems. In the **power sector**, where governance of decarbonisation has arguably progressed furthest and the guidance and signal is strong and clear for the phase-in of renewable energy (and where there may even be an oversupply on transparency and accountability), guidance on the need to phase out fossil fuel-powered electricity generation has remained vague (for coal) or virtually absent (for oil and gas). Governance of the phase-out of **fossil-fuel extractive industries** has remained wanting across all

functions. Although fossil-fuel subsidy reform has made some headway, its potential to reduce emissions has yet to be meaningfully exploited, due to the difficulty of agreeing specific rules. For **energy-intensive industries**, the pattern is the same, with a particularly lamentable undersupply of rules and standards. In **land-based transport**, global climate governance does little to challenge dominant high-emission policy and planning paradigms and to shift public resources to sustainable modes, and lacks rules on sector-specific targets and strategies. **International transport**, where opportunities to better internalise external costs exist, has yet to exploit the promise of market-based instruments or other effective measures such as relatively 'low-hanging' operational measures to control speed in shipping. The shortcomings of international governance of global finance for climate purposes (Kretschmer 2021) presents problems across sectoral systems.

Phasing out support for ‘brown’ investments constitutes a tougher challenge than raising funds for investments in low-carbon alternatives.

The (average) supply of the different governance functions also varies significantly. The means of implementation and knowledge and learning functions are the best provided for. This may reflect the relatively low costs of advancing the latter, and the possibility to build on an existing institutional infrastructure in the case of the former (including the financial and technology mechanisms of the UNFCCC, multilateral development banks, and others). Having said that, there remains uncertainty over exact sums being dedicated to R&D in some critical cases (such as energy-intensive industries and aviation). While the Paris Agreement has delivered important general guidance and signal, sectoral specification remains lacking in most cases. International governance has, however, been most deficient in supplying adequate rule-setting (and related transparency). This may not be surprising since agreement on such regulation is hard to achieve given its potentially far-reaching distributional consequences and opposition from incumbents. Consequently, where international regulation has advanced, its substance has often remained inadequate, as for example in regulation for the decarbonisation of international transport.

Overall, despite significant governance activities in most sectoral systems, crucial gaps remain. Key governance potentials remain underexploited, especially with respect to hard-to-achieve regulation. A rising number of transnational governance institutions has contributed to global climate governance but has not been able to fill the gaps. This seems to confirm previous research that has pointed out that polycentric governance systems are not necessarily self-organising so as to provide critical governance functions (Jordan et al., 2018). Our approach has enabled us to systematically identify the existing key gaps and potentials.

5. The UNFCCC and the Paris Agreement: important but not sufficient

The UNFCCC and its Paris Agreement address all five governance functions for climate policy in its broadest sense, and feature in important respects (though to varying degrees) across all sectoral systems examined in this special issue. Yet, its contribution to the identified governance needs varies per function. Perhaps its most salient and also important contribution consists of the overarching guidance and signal it offers. Its key message – that deep decarbonisation is required for reaching long-term temperature goals (cf. Hermwille et al., 2017) – resonates to some extent in all sectors. Particularly ground-breaking but often overlooked, its Article 2.1(c) directs all financial flows to become consistent with the Agreement’s mitigation and adaptation objectives. This has initiated a paradigm shift in recognising and highlighting the key role of the global financial system, traditionally seen as a “neutral” intermediary, in bringing about the global climate transition (also see Chenet et al., 2019; Kretschmer 2021).

However, our sectoral assessment has highlighted the need for more specific guidance which the Paris Agreement does not currently provide. As mentioned in section 3 above, the implications of the Agreement’s long-term goals for coal (and renewables) are relatively straightforward but less clear for oil and, especially, gas. Similarly, energy-intensive industries, land transport (for which the UN Habitat New Urban Agenda and the SDGs may prove more impactful) and international transport receive no specific guidance. The Agreement’s aforementioned finance goal is also in need of further interpretation and specification to give clear guidance to the financial system (see Kretschmer, 2021).

The enhanced transparency framework established under Article 13 will likely further improve transparency and

accountability as well as knowledge and learning in a range of sectors, but mainly at the aggregate level. Parties to the Paris Agreement are mandated to report transparently and comprehensively on their emissions but not on other key indicators that may reflect more directly the progress of sectoral transformation (e.g. emission per passenger km travelled or share of renewable/zero emission energy) (see Jeffery et al., 2019). Also, the established territorial approach to accounting for emissions does not recognize or reward actions which might lead to emission reductions ‘offshore’ (such as restricting fossil fuel exports).

While the UNFCCC and its Paris Agreement make important contributions to securing adequate means of implementation, these need to be complemented. The Green Climate Fund and other funds under the UNFCCC constitute important channels and means (see Kretschmer 2021), as does the Technology Mechanism (Wyns et al. 2019). Capacity building is also advanced (Khan et al., 2016). However, the sectoral analyses provide clear evidence that, even if means of implementation under the UN regime were adequately strengthened, further action beyond will be required (e.g. involving Multilateral Development Banks and private banking for the financial system).

As far as sectorally specific rules and standards to facilitate collective action are concerned, the Paris Agreement’s relevance is severely limited. The Agreement contains few mandatory legal requirements on Parties; those it sets out primarily relate to the submission of nationally determined contributions (NDCs) and reporting obligations (Oberthür and Bodle, 2016). In addition, the 5-yearly cycle of taking stock of collective progress and communicating new and updated NDCs stimulates and offers opportunities to synchronise climate policy processes on the national and international level (Obergassel et al., 2016). However, overall the Paris Agreement and the wider UNFCCC have done very little that would meet the sectoral needs and potentials identified in our sectoral analyses (see Table 2).

Given its primary focus on GHG emissions in general and the historically relatively minor role of sector-specific perspectives,² the limited contribution of the UNFCCC to sectoral governance is not altogether surprising. The Paris Agreement hardly makes reference to specific sectors and its long-term goals remain generally detached from sectoral systems. Nevertheless, these goals provide important general guidance, including for the elaboration of more sector-specific guidance possibly by more sectorally focused institutions. Similarly, the UNFCCC and its Paris Agreement make important contributions to transparency and providing means of implementation, which need to be complemented by more sector-specific arrangements.

6. The ambivalent role of non-environmental institutions

Non-environmental/climate related institutions played important but ambivalent roles in most, if not all, sectoral systems analysed. Frequently pre-dating the UN climate regime, these institutions’ policies and activities have, on the one hand, at times impeded decarbonisation efforts and have generally so far not been particularly well aligned with the decarbonisation imperative. On the other hand, they possess important sectoral authority that might in principle be employed to advance decarbonisation. Overall, the contributions to this special issue confirm the need for a further mainstreaming of climate objectives into non-environmental institutions.

² The “Koronivia joint work on agriculture” mandated by COP decision 4/CP.23 is a rare exemption of sectorally focused technical work under the UNFCCC, with its exact outcome yet unclear at the time of writing.

The World Trade Organization (WTO) was found to have significance for several sectoral systems, with ambivalent implications. On the one hand, WTO disciplines have continued to inhibit the implementation of border carbon adjustment mechanisms to address competitiveness and carbon-leakage concerns of energy-intensive industries arising from effective national climate policies – even if there may be ways of designing WTO-compatible measures (Mehling et al., 2019). Moreover, WTO-related arguments have been employed to hinder the development of market-based measures to address GHG emissions from international shipping (even if apparently wrongly so) (Chircop et al., 2018). Similarly, investment treaties, and specifically their investor-state dispute settlement provisions, have raised concerns of chilling the development and implementation of ambitious climate policies (see extractive industry analysis). On the other hand, the WTO system allows preferential trade agreements that could facilitate the deployment of renewable energy and other low-carbon technologies (Hermwille, this issue; Morin and Jinnah, 2018). Furthermore, negotiations on a so-called Environmental Goods Agreement launched in 2014 could serve to reduce tariffs and trade barriers on low-carbon technologies (Van de Graaf and Colgan, 2016). And the WTO Agreement on Subsidies and Countervailing Measures has a high potential to support the phase-out of fossil-fuel subsidies, even if countries' obligations under the agreement may need to be clarified to this end (Casier et al., 2014).

The role of ICAO and IMO for the decarbonisation of international aviation and shipping, respectively, is similarly ambivalent. ICAO's Chicago Convention, in force since 1947, primarily aims to facilitate the expansion of global civil aviation and related decisions have exempted fuel for international flights from taxation, as enshrined in a large number of bilateral aviation agreements. At the same time, it has the authority to regulate international aviation and has started to address the sector's GHG emissions, in particular by elaborating the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). IMO, for its part, aims to develop and regulate international shipping and has started to address its GHG emissions as well, although further concrete measures remain to be elaborated and implemented. To date, action within both international organisations has been insufficient for effectively advancing international transport's climate transition.

Much the same can be said of relevant international financial institutions, including the World Bank and other Multilateral Development Banks (MDBs). The means available to them to help bring about the global shift to low-carbon investments is enormous and they have made appreciable progress towards adapting their policies accordingly. However, additional, more resolute changes are required so that funding for low-carbon investments is sufficiently increased and support for carbon-intensive investments (in fossil-fuel extraction and consumption, e.g. in energy-intensive industries) is ended. Other international institutions, such as UNIDO in the case of energy-intensive industries, face very similar challenges.

The role of other institutions is similarly ambivalent. The G7 and G20 primarily focus on other issues, including some that may be at odds with the climate transition (e.g. economic growth, trade). However, they also conduct work that has potential to advance that transition (fossil fuel subsidies, climate discussions among major emitters, G20 Financial Stability Board). Yet, progress on advancing decarbonisation has remained very limited, as is evident from the lack of progress on the phase out of fossil fuel subsidies to which the G20 committed in 2009. Similarly, the IEA has the potential to play a central role for the power sector but also for energy-intensive and extractive industries. The IEA already serves as a central information hub and has considerable convening power. Yet, its legacy as an oil buyers' club and its membership limitations (only

OECD members can become full members) still impede its taking on a more transformative role (see power sector analysis).

Overall, there remains a considerable scope, and need, to align non-environmental institutions towards the climate transition. None of them seems to be directly opposed to effective climate policies, but varying levels of tension with their core objectives and routines can be observed.³ Pressure arising from (the threat of) unilateral action has been helpful in initiating change in the case of international transport. For the climate transition to advance/succeed, the challenge more generally is to more fully integrate climate objectives into the policies and routines of these non-environmental institutions so as to direct their authority towards the decarbonisation goal.

7. Options to enhance international climate governance

The sectoral approach advanced in this special issue has served to yield a solid overview of the institutional landscape for each sectoral system and to systematically identify related governance gaps. This also provides a basis for further deliberations on how the identified gaps and weaknesses might be addressed. Accordingly, the sectoral analyses briefly address options for improvement, focusing on whether: (1) the scope of existing institutions might be expanded, or their focus shifted for this purpose; (2) the creation of new institutions might be warranted; and (3) the coordination of existing institutions holds promise. These options are not mutually exclusive, but may be complementary. While this discussion of policy options only constitutes a beginning, it provides a useful starting point for a more encompassing future assessment (see section 9 on future research below).

The UNFCCC has some (limited) potential for advancing governance in several sectoral systems, especially extractive industries (and beyond the articles in this special issue, global finance – see Kretschmer 2021). Untapped potential to tackle the neglected 'supply side' of climate policy (Lazarus and van Asselt 2018) and facilitate economic diversification away from fossil-fuels extractive industries could be exploited, including through the UNFCCC's forum on response measures, the Green Climate Fund and the Global Environment Facility. Article 2.1(c) of the Paris Agreement, aligning all financial flows with the objectives of the agreement, still needs to be translated into meaningful sectoral terms and requires additional guidelines on how to track all domestic and international finance flows in relation to the 1.5 °C target. This should have a significant effect on all sectoral systems covered in this special issue. Especially the analyses of land transport, power, and finance furthermore suggest that the UNFCCC might help motivate and coordinate sectoral targets towards the Paris Agreement's long-term temperature and emission goals. In this context, the UNFCCC could endorse sectoral visions developed in other international forums, thereby raising their profile. These suggestions seem compatible with a conceptualisation of the multilateral regime as an overarching framework, with potential to further orchestrate polycentric global climate governance (see also Hermwille et al., 2017), in need of sectoral specification and supplementing.

Other overarching institutions also have further potential. The analyses of the finance and fossil-fuels extractives sectoral systems highlight that the G7 and the G20 (working with the WTO) could in principle serve to tighten commitments to phasing out fossil-fuel use and fossil-fuel subsidies, and hasten implementation. The

³ This is particularly true for the Energy Charter Treaty. Its investor-state dispute settlement provisions enable corporations to sue governments for 'loss of future profits' (Eberhardt et al., 2018).

G20 was also highlighted as a critical forum for efforts to manage the risks to the global economy presented by the 'carbon bubble'. While both the UNFCCC and the G20 may have a role to play in this respect, each would need significant upgrading to take on a leading role. Furthermore, adjustments to the mandates and policies of the World Bank and other Multilateral Development Banks are worth considering in a number of sectoral systems, including energy-intensive industries and international shipping, so as to direct finance and investment towards the climate transition.

For several sectoral systems, our analyses identify a significant potential for advancing governance through existing *sector-oriented* institutions. In addition to the international financial institutions discussed above, a reformed IEA could elaborate more detailed roadmaps, and advance global agreements to phase out fossil fuel use – but the far-reaching reforms required to this end, including a break with the OECD, may call feasibility into question. For energy-intensive industries, very few initiatives exist that could be enhanced. In international transport, ICAO and IMO have latterly begun providing a degree of leadership on climate governance for aviation and shipping, respectively – but have been limited by the continuing hold over key decision-making processes exercised by incumbent actors. Pending more radical institutional restructuring of these bodies (which remains some way off), there is a case for encouraging regionally-based regulatory initiatives, such as the EU's. By facilitating decarbonisation, such initiatives could eventually also generate greater ambition at the global level.

Despite calls for "institutional economy", the creation of *new institutions* may be contemplated where suitable existing institutions are not available, or where required reforms of existing institutions seem too far-reaching in view of their current objectives and design (on the case of IRENA, see [Van de Graaf, 2013](#)). Proponents of new institutions should beware, however, of endemic obstacles to progress re-appearing within new institutional arrangements, if their establishment is even deemed acceptable to veto players ([Michonski and Levy, 2010](#)). The analyses of international transport and fossil-fuel extractive industries, for example, highlight the lobbying power of incumbent, fossil-fuel reliant industry actors (see also [Harich, 2010](#)). In the case of energy-intensive industries, the establishment of one or several new, sectoral institutions with participation of governments and key industry players may be considered, in the form of one overarching institution and/or sub-sector specific initiatives (possibly including transnational sectoral decarbonisation clubs: [Oberghassel et al., 2019](#); [Hermwille, 2019](#)). In the case of fossil-fuel extractives, a 'non-proliferation treaty' has been proposed ([Newell and Simms, 2019](#)), but its prospects of getting off the ground in the face of dominant political-economic forces currently look uncertain, at best.

As a third type of response, coordination and orchestration of existing institutions features as a prominent option especially where institutional density is relatively high. Hence, the sheer number of institutions involved in the governance of the power and transport sectors (land-based and international maritime), especially focused on capacity building and knowledge and learning, suggests a considerable potential for coordination to avoid duplication of effort and increase performance. In addition, potential for enhanced orchestration led by the G20 has been identified in the case of fossil-fuel extractive industries, with MDBs and other donors providing targeted support for the transition away from these industries. Overall, the UNFCCC, as the overarching umbrella of international climate governance, may be suitable for coordinating sectoral initiatives to some extent, including in the field of climate finance populated by the Green Climate Fund, MDBs, Mission Innovation and others. The analysis of international shipping furthermore highlights a need to pay attention to coordination of

activities across levels of governance (and hence beyond a sole focus on *international* governance – see also the discussion on future research below).

Which approach and mixture of the above is most promising will ultimately depend on the pre-existing institutional landscape and other sectoral characteristics. Undertaken in a sectorally-specific way, governance needs to overcome particular barriers, address widely varying numbers of relevant actors, etc., weighing the efficiency benefits of retaining existing institutions against the need to break more definitively with established, unsustainable practices.

8. Merits and limitations of the sectoral approach

This special issue has demonstrated the usefulness of a sectoral approach to international climate governance. Digging deep into socio-technical sectoral systems has brought to the fore important transformation challenges that can and should be addressed by international governance. That global climate governance has fallen short of facilitating a global transformation towards meeting the climate objectives of the Paris Agreement is no surprise. Yet, combining a sectoral perspective with the identified governance functions provides a useful structure for a more detailed and systematic diagnosis of precisely why it has fallen short, and in which respects. Systematic assessment of sectoral systems draws particular attention to what is required by actors 'on the ground', and has enabled us to highlight specific governance gaps and think about options to further enhance international governance.

Yet, there are also inherent limitations with our approach. As noted in our introductory paper ([Oberthür, Hermwille and Rayner, this issue](#)), the question of what constitutes a sectoral system, and how this differs from sectors as defined in other contexts, is not one that can be definitively resolved, once and for all. Delimiting satisfactory boundaries of analysis is likely to be particularly challenging in certain cases. For example, defining the boundaries of the global financial system may face particular difficulties due to its amorphous structure, involving a set of actors ranging widely from public development and climate finance institutions, multilateral, national and corporate banks and insurance companies, through to hedge funds and other financial service providers. Moreover, there are deep rooted interdependencies between the financial and other sectoral systems. Nevertheless, the (emerging) institutional sub-complex on governing global finance is obviously critical to the climate transition ([Kretschmer 2021](#)).

More importantly, beyond financial aspects, a focus on sectoral systems may not naturally highlight significant overlaps and interdependencies between these systems. All the sectoral systems analysed in this special issue experience interdependencies, such as between the power sector on the one hand and energy-intensive industries and transport on the other, given trends towards electrification. These interdependencies may have positive or negative implications. In negative terms, competition to secure feedstocks for biofuels, to purchase carbon market credits (as in the case of international transport), or reliance on the prospect of negative emission technologies (for 'hard-to-abate' sectors in general) establish links across sectoral systems that may compromise the deliverability of sectoral decarbonisation targets. In more positive terms, action by a sector such as shipping to develop hydrogen-based solutions at scale can draw in a range of other sectors, able to exploit the economies of scale achieved to deploy such solutions more widely. Although we have explicitly paid attention to such interactions and interdependencies, we must admit that the sectoral approach may not be the most pertinent tool for investigating cross-sectoral implications, including the related need for coordination to foster coherence across polycentric governance systems (see also [Jordan et al., 2018](#)).

A further issue concerns the framing of our five governance functions. Their use implies a level of aggregation that may hide important specifics within each. For example, *means of implementation* include three important and different general components, namely technology, finance, and capacity building. Similarly, *knowledge and learning* encompasses data gathering and science, technology development, knowledge about effective policy design and awareness raising. This makes it difficult to provide an overall, aggregate assessment of the fulfilment of these governance functions, but it is also in danger of glossing over important aspects. In response, we have attempted to pay due attention to all the sub-components of the governance functions in our analyses and to make any judgements involved in weighing them explicit. Our analyses have provided evidence that, ultimately, more granularity is required in the exploration and assessment of the five governance functions than may be suggested by their headlines.

Our analysis has also prompted some reflection on interlinkages between the governance functions. For example, the extractive industry sectoral analysis highlights the importance of a level of *knowledge and learning* as a precondition for further progress on delivering *guidance and signal* and *rule-setting*. The relationship between *transparency and accountability*, *rule-setting*, and *knowledge and learning* was found to be subtly nuanced. In the case of international transport, data about industry performance, including emissions, were a pre-requisite for effective rule-setting. Thereafter, continued and refined data gathering would also serve to support transparency and accountability. The same broad point stands for global finance (Kretschmer 2021). In more general terms, *knowledge and learning* and *transparency and accountability* especially were found to be closely related in many sectoral systems, since they may rely on the same data and information (that may hence serve a double-function).

Mitigating climate change faces very varied challenges and opportunities in different sectoral systems. Overall, systematically analysing governance needs, supply and gaps in specific sectoral systems with respect to five general governance functions has allowed the identification of both weaknesses and opportunities in the international governance landscape that either escape notice, or are under-emphasised, in other analyses and approaches. Despite its limitations, we think that this special issue has demonstrated that the proposed sectoral approach can make an important contribution to arriving at a more systematic analysis of the adequacy of global climate governance for the considered sectoral systems as well as at the overall level.

9. Directions for future research

While we are confident that this special issue has provided evidence for the added value of a sectoral approach to global climate governance, we recognize that this is but a first attempt at its development and application. A wealth of possible avenues for future research suggest themselves, to further deepen and expand the approach. Without trying to be exhaustive, we highlight four areas for such future research that appear particularly promising to us.

First, there is enormous potential to further investigate the politics of sectoral climate governance. In this special issue, we have focused on investigating barriers and challenges to decarbonisation per sectoral system, the current contribution of governance institutions to addressing these, and the general scope for enhancing this contribution. We were not able to explore as fully as we would have liked the political interests and struggles which underlie the inadequacy of current governance provisions, and presumably shape and constrain any attempts at improvement. More explicitly exploring the role of agency and power would enable a more

detailed understanding of the *political* barriers to effective governance and the reasons for current deficiencies. Part of this investigation of the politics of sectoral governance could and should be the systematic exploration of equity aspects (“just transition”, “climate justice”) important for ensuring broad societal and international support, without which the climate transition is likely to falter (as highlighted in our analyses covering the extractive industries and power sectoral systems).

Second, and following from the first point, there is considerable scope to clarify further options for institutional reform, be it by developing existing institutions or creating new ones, to enhance sectoral climate governance. Our analysis has only been able to identify some general options to address sector-specific barriers to decarbonisation, taking into account the broad potential of existing institutions (in view of their composition, objectives and capacities). The aforementioned exploration of underlying politics could provide a basis for investigating further the feasibility of institutional options and strategies for their realisation, taking into account political economy-related constraints. Other factors shaping and constraining attempts at institutional reform may also deserve systematic attention, including existing institutions’ rationales, path dependencies, established practices and constituencies (Voß and Simons, 2014); inter-institutional interdependencies; and deeply engrained growth-oriented economic paradigms and societal practices (Hickel and Kallis, 2019). In addition, questions of institutional design remain to be clarified in much more detail; there is a need to systematically elaborate and compare institutional options to minimize identified gaps and more fully exploit governance potentials.

Third, significant promise lies in developing the sectoral approach from a more multi-level, fully polycentric governance perspective. In this special issue, we have focused on global climate governance through intergovernmental and transnational institutions. However, this is but one level of governance, accompanied by governance at regional (e.g. European), national and subnational levels. Following Roger et al. (2017), activities at other levels contribute significantly to the supply of governance functions. For example, knowledge and learning may be advanced at various levels, and the combined actions of a larger number of actors at lower levels of governance may provide an effective signal in itself. In our sectoral analyses, the significance of activity across different governance levels came into focus in the international shipping case and in land transport, for example. However, much more needs to be done to investigate what different governance levels could contribute and how each could usefully complement and re-enforce the others, possibly balancing out respective weaknesses. Considerable potential also remains to develop a geographically and regionally more differentiated understanding of sectoral climate governance; specifically, are some regions of the globe leading in terms of responding to sectoral climate challenges, while others lag?

Recent scholarship on polycentricity in climate governance has called for more attention to the development of climate governance responses *over time*; whether, for example, trust and mutual adjustment can occur among actors without top-down direction, and various transnational initiatives endure (Jordan et al., 2018). These are certainly germane questions in taking forward sectoral systems-oriented research. Similarly, we might ask to what extent governance arrangements in one sectoral system take into account the behaviour of other systems, and are able to engage in mutual adjustment across sectors, for example to coordinate the use of offsetting or allocate scarce biofuel resources to those with the most valid claim (a possibility so far not examined by polycentric analyses as far as we know).

Fourth, a sectoral approach to international climate governance also provides a new lens for assessing the performance of

individual actors and especially their international leadership. For example, the European Union (EU) has long claimed and pursued international leadership on climate change. Related analyses have to date tended to focus on the role of the EU in the multilateral UNFCCC regime (e.g., Bäckstrand and Elgström, 2013; Parker et al., 2017; Oberthür and Groen, 2018). Our sectoral approach draws attention to the efforts of such actors across the wider, multi-institutional governance landscape, differentiated by sectoral system. It thereby provides a more comprehensive benchmark, and a basis for a more fine-grained, systematic assessment, of international climate leadership.

Overall, the sectoral approach to international climate governance hence opens up a rich and fascinating agenda for future research. We trust that this special issue has been able to demonstrate the added value and potential of this sectoral approach to advance our understanding of multi-institutional polycentric climate governance. We are confident that there is scope for making use of and developing the approach beyond the areas highlighted above, and that advancing the sectoral approach, with its focus on specific barriers and sectoral conditions, also has the potential to help improve global and multi-level polycentric climate governance in practice.

CRediT authorship contribution statement

Tim Rayner: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Sebastian Oberthür:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Lukas Hermwille:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

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